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A MODEL OF THE LOCAL CIVIL DEFENSE OPERATING SYSTEM

Robert N. Hendry, et al

Research Triangle Institute

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A MODEL OF THE LOCAL CIVIL DEFENSE SYSTEM

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13. ABSTRACT

The Research Triangle Institute under contract with the Defense Civil Preparedness Agency is designing and developing a countermeasures model which is part of the analytical structure (TELOS) to evaluate solution alternatives to damage problems. The objective is to provide a means for placing relative values on alternative countermeasure concepts evolving within the Agency. Such an evaluation will provide better information to support recommendations for civil defense programs.

This report describes the prototype design of the time-phased Local Countermeasures Model. Major accomplishments during this contract period were the programming of three submodels; these are in addition to the five developed under previous contracts. Some additional work is required to integrate LDAM into the analytical procedure, to complete and test the operations submodel, and to complete and test the transportation submodel. Work to date has enabled demonstration of many of the elements, procedures, and assignment criteria used in describing local civil defense operating systems.

The requirements submodel updates internal status records and determines functional requirements based on "new" problem and resource files generated in the problem definition submodel. The team assignment submodel adapts an existing allocation procedure for assigning teams (representing resources) effectively to operations which solve existing problems. The deployment submodel distributes the assigned resources to the locations where they can be utilized. The final steps in the operations submodel are to execute the assignments, to assess the benefits gained from the allocation of available resources, and to prepare the benefit-readiness report.

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DETACHABLE SUMMARY

FINAL REPORT 43U-614

March 1973

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by

R. N. Hendry and D. B. Wilkerson

for

DEFENSE CIVIL PREPAREDNESS AGENCY
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under

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Dora B. Wilkerson

March 1973

Work Unit 4126I
Contract No. DAHC20-71-C-0222

SUMMARY

Improved techniques are needed to develop realistic procedures for coping with damage from nuclear attacks on local urban areas of the United States. The Research Triangle Institute (RTI), under contract with the Defense Civil Preparedness Agency (DCPA), is designing and developing a Local Countermeasures Model (LCM) which will be part of a larger analytical structure to evaluate solution alternatives to damage problems.

This model (LCM) has been directed toward the evaluation of various local countermeasures integrated into a total operating system. Heretofore, system evaluations have concentrated on individual countermeasures; other countermeasures have either been omitted or included only in supporting roles. In contrast, this evaluation procedure is designed to integrate all countermeasures into one system.

Technical Operations, Inc. (TOI) initiated development of an inventory file which relates attack environments to target area resource vulnerability to dynamically define the status of civil defense resources. The development work has been extended by the Institute for Defense Analyses (IDA).

The overall analytical framework requires, as input, time-phased problems which are derived from the TCI/IDA damage assessment model. These problems are formed into sets of problems affecting specific resources described by the target model. The human population is the prime resource but other resources (including facilities, equipment, goods, and materials) affect man's survival. Operations are formulated which not only will enable the survival of resources but also minimize the level of injury or damage to them. All problems are required to have solution sets and all solutions are required to expend limited resources.

Comparisons can be made between dissimilar functions if they are a part of a set of operations that yield similar results and expend equivalent resources. Choices are made between comparable operations on the basis of a measure-of-merit formulated from probable benefits and expenditures of available resources.

The output of the Local Countermeasures Model is derived from the beneficial results of assigned operations and the availability of countermeasures resources relative to the operational demands for them. The latter relationship is called readiness. Thus, increased readiness and relief and rehabilitation of survivors are the benefits derived from the countermeasures activities. Results are partitioned to determine the contribution of each subsystem to overall system performance and to interface with the other analytical frameworks required for total system evaluation.

Major accomplishments during the contract period were the programming of three submodels, in addition to the five developed under earlier contracts. As a consequence, the prototype Local Countermeasures Model is approximately eighty-five percent (85%) complete. (An exact estimate is difficult, or impossible, because the desired product is not precisely defined and the roles are not stated explicitly.)

The Local Countermeasures Model, at least in a preliminary form, will demonstrate the elements, procedures, and performance measures which can be used in evaluating local civil defense operating systems.

At least four uses of the Local Countermeasures Model are envisioned. First, it may be used to coordinate the many submodels developed in the

countermeasure component areas (e.g., rescue, medical treatment, fire-fighting, debris clearing, and decontamination). Second, it may be used to generate data from which damage functions may be prepared for the EVUNS (Evaluation of the Vulnerability of National Systems) procedures. Third, it may be used to evaluate and test revisions to local civil defense plans for specific local areas or for the general planning documents such as ALFA NEOP, on which they may be based. Fourth, it may be used to train civil defense personnel. Explicit guidance will be needed to direct the model toward one or more of these applications. Each role identified above should be evaluated to accept or reject its applicability and to assign priorities to the accepted roles.

Practical use of a model of a local operating system can be achieved best through the development of procedures to Test and Evaluate Local Operating Systems (TELOS). A complete description of TELOS is beyond the scope of this effort. However, it may be described as the Local Countermeasures Model including the Local Damage Assessment Model (LDAM) along with four additional models. They include: (1) an attack model (known as ANCETOPS) to synthesize the nuclear attack environments for LDAM; (2) a data base synthesizing model (not yet developed); (3) an evaluation model (which is not as yet developed) to analyze and correlate the outputs from the Local Countermeasures Model; and (4) a control model (which is not as yet developed) which superimposes control requirements on all other parts of the TELOS procedures.

RTI recommends the development and implementation of a multi-year program plan to realize all of the potential benefits from the Local Countermeasures Model. RTI also recommends the integration of LDAM into the LCM, the completion of the LCM, the preparation of a data base and the demonstration of the combined local operating system model.

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FOREWORD

The research reported herein covers the "design" phase of the synthesis of a near-future total civil defense system for the Defense Civil Preparedness Agency (DCPA) under Contract Number DAHC20-71-C-0222, Work Unit 4126I. Details of the computer programs developed have been provided separately to the sponsor.

Work Unit 4126I is closely related to the Five-City Study. This effort focuses attention on the 4120 task which has as its objective the development of local CD system evaluation techniques. However, it is limited to analysis and modeling of a countermeasures system during the operating phase.

The authors express their indebtedness to Mr. Neal FitzSimons and Mr. Donald Hudson of the DCPA Research Directorate for guidance during the study. The authors also express their appreciation to Mr. Edward Hill and to others in the Research Triangle Institute who supported this research.

ABSTRACT

The Research Triangle Institute under contract with the Defense Civil Preparedness Agency is designing and developing a countermeasures model which is part of the analytical structure (TELOS) to evaluate solution alternatives to damage problems. The objective is to provide a means for placing relative values on alternative countermeasure concepts evolving within the Agency. Such an evaluation will provide better information to support recommendations for civil defense programs.

This report describes the prototype design of the time-phased Local Countermeasures Model. Major accomplishments during this contract period were the programming of three submodels; these are in addition to the five developed under previous contracts. Some additional work is required to integrate LDAM into the analytical procedure, to complete and test the operations submodel, and to complete and test the transportation submodel. Work to date has enabled demonstration of many of the elements, procedures, and assignment criteria used in describing local civil defense operating systems.

The requirements submodel updates internal status records and determines functional requirements based on "new" problem and resource files generated in the problem definition submodel. The team assignment submodel adapts an existing allocation procedure for assigning teams (representing resources) effectively to operations which solve existing problems. The deployment submodel distributes the assigned resources to the locations where they can be utilized. The final steps in the operations submodel are to execute the assignments, to assess the benefits gained from the allocation of available resources, and to prepare the benefit-readiness report.

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A Model of the Local Civil Defense Operating System

I. INTRODUCTION

Improved techniques are needed to develop realistic procedures for coping with damage from nuclear attacks on local urban areas of the ited States. The Research Triangle Institute (RTI), under contract with the Defense Civil Preparedness Agency (DCPA), is de- ' gning and developing a Local Countermeasures Model which will be part of a larger analytical structure to evaluate solution alternatives to damage problems.

The objective is to provide a means for placing relative values on alternative countermeasure concepts evolving within the DCPA. Such an evaluation will provide better information to support recommendations for civil defense programs. Other uses of the model include:

a) damage function development for national systems evaluation,

b) training support for civil defense decisionmakers, and

c) assistance in developing and evaluating local civil defense plans.

RTI[1/] has employed the simplified analytical structure developed by Mr. Devaney,[2/] formerly of OCD (now known as DCPA), in synthesizing a current local operating system. Subsequent effort by RTI has resulted in a preliminary design of a countermeasures model.[3/] This model is part of

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1/ R. N. Hendry. Civil Defense Operating System Synthesis: Countermeasures Model. Research Triangle Park, North Carolina: Research Triangle Institute, October 1968.

2/ J. F. Devaney. Civil Defense Research Analysis: Washington, D. C.: Research Directorate, Office of Civil Defense, December 1966.

3/ R. N. Hendry and Dora B. Wilkerson. Local Operating System Countermeasures Model. Research Triangle Park, North Carolina: Research Triangle Institute, November 1969.

a larger framework designed to evaluate alternative local civil defense operating systems. Interfaces between the attack environment, damage assessment, target, and cost models in the larger system evaluation framework (now known as TELOS) require an adequate definition of compatible links between mutually supporting elements.

Resource damage problems are accepted and solved by the model by assigning missions to organized sets of teams. This procedure measures mission benefits gained as a function of team readiness to achieve them.

A companion effort[4] by Technical Operations, Inc. (TOI) developed an inventory file (further developed by the Institute for Defense Analyses), which relates attack environments to target area resource vulnerability to dynamically define the status of civil defense resources. The effort has resulted in a local damage assessment model called LDAM.

The Local Countermeasures Model requires, as input, time-phased problems which are defined by LDAM. These problems are formed into sets of problems affecting specific resources described by the target model. The human population is the prime resource, but other resources (including facilities, equipment, goods, and materials) affect man's survival. Operations are formulated which not only will enable the survival of resources but also minimize the level of injury or damage to them. All problems are required to have solution sets and all solutions are required to expend limited resources.

Comparisons can be made between dissimilar functions if they are a part of a set of operations that yield similar results and expend equivalent resources. Choices are made between comparable operations on the basis of a measure-of-merit formulated from probable benefits and expenditures of available resources.

The countermeasures model described herein is constrained to utilize the damage assessment resource file as a basis for establishing the input resources and the prevailing environments in which the countermeasure operations must operate. Therefore, the output is presumed to be a

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4/ Hans J. Tiller, et al. Development of a Local Civil Defense Operating System Evaluation Model (Draft). Alexandria, Virginia. Technical Operations, Incorporated, January 1970.

modified resource file in which the states of resource items are improved by countermeasures taken by local forces in response to civil defense problems.

The output of the Local Countermeasures Model is derived from the beneficial results of assigned operations and the availability of countermeasures resources relative to the operational demands for them. The latter relationship is called readiness. Thus, general population, system readiness, and team effectiveness values are output from the Local Countermeasures Model. Results are partitioned to determine the contribution of each subsystem to overall system performance. However, since the evaluation procedures have not been explicitly defined, an adequate interface with the other elements of the Test and Evaluation of Local Operating Systems (TELOS) remains to be determined.

II. COST-BENEFIT MEASURES

A. General

The Local Countermeasures Model, as a part of the system for TELOS, must produce output performance measures in terms of resource expenditures and benefits derived from these expenditures. The measures described in the following paragraphs of this section were derived in anticipation of the evaluation requirements rather than in response to them. Therefore, as evaluation criteria are developed these measures may be expanded or altered to suit specific requirements.

Local operating systems are envisioned as a set of civil defense teams and facilities operating within (but also a part of) the population and its resources. Necessarily, simple measures of the quantity of surviving people, facilities, equipment, and supplies have been and will continue to be used to describe resources status. They are not believed to be sufficient for system evaluation. The following subsections describe survivor benefit measures; relative-well-being; readiness; a performance measure called team-effectiveness; cost and price; and other potential indices.

B. Survivors

Local civil defense systems have a responsibility "to improve their individual circumstances for survival, and to relieve their distress, in the event of enemy attack on the city."[5/] Therefore, it is reasonable to include the number of survivors as a measure of the degree to which local authorities have met this responsibility. The comparative measure of survivors-added (or lost) indicates a relative benefit between two times, between two alternative actions, or both. Neither survivors nor survivors-added respond to the other part of the executive order referenced above; i.e., "to relieve their distress." "Distress" is taken to mean the status of a surviving citizen including health and welfare. Using this order as a base, three measures of survivor state have been developed. The first is

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5/ Executive Order No. 7 dated October 26, 1962, City of Detroit.

labor potential or health. This measure is designed to recognize the many injured and disabled survivors who are in distress. The second is employment potential. This measure is designed to quantify the jobless who are in distress because the productive capacity of the local area has been destroyed. The third is housing potential. This measure reflects the degree to which area residents have been deprived of housing.

A team is the basic civil defense operating element in the Local Countermeasures Model. The number of surviving teams is another measure which is believed useful in describing system performance. Correspondingly, the team-hour is the basic resource unit which is expended during operations to either increase survivors or relieve their distress. Measures indicating the state of civil defense teams are important in explaining the operating effectiveness of local sy-tems. Five descriptors are used to define team states: active, mobile, inactive, inoperative, and restricted. Each team-hour of each surviving team is classified as being in one of these states. An active team-hour status signifies that a team has been actively employed for an equivalent of one hour in solving survival or relief problems. A mobile status is defined as moving from one place to another either for redeployment purposes or to transport people from one area to another. An inactive status is believed self-explanatory. A team in an inoperative state is one that is short of personnel, equipment, supplies, or facilities and, thereby, cannot function effectively. Finally, a team in a restricted status identifies the effect of high radiation levels on team activity. Three other measures relate to the demand for team-hour resources. The first of these is indicated as a "shortage." A "shortage" is defined as a demand for team-hours that cannot be satisfied by available resources during the current period. The second is a "pending" status in which team-hours were assigned to satisfy a demand during the current period but were unable to complete the assignment. The third measure is the quantity of team-hours expended during the current period to complete or satisfy a demand. Thus, all team-hours in a "completed" status are either mobile or active and are required to satisfy a demand.

All of the above simple measures should be included in the output. If they are used for each unit area, statistical measures including means and standard deviations of these values may be of some value in evaluating local operations depending on the use to which TELOS is adapted.

C. Relative-Well-Being

The combination of the simpler measures of population status is called "relative-well-being" (RWB). It is described by the following mathematical relationship:

RWB = (1 + L + V + W)

where Survivors, S = fraction of population surviving;

Labor Potential, L = average level of physical capability of the survivors expressed as a fraction of preattack normal capability;

Job Potential, V = average level of value-added productive capacity surviving expressed as a fraction of the preattack value-added productive capacity; and

Housing Potential, H = average level of housing expressed as a fraction of surviving population housed in residential housing units assuming the preattack average number of persons per housing unit.

Constants are added to each component measure to normalize the overall measure and cause it to range from 0 to 1. Different values of these constants enable the weighting of terms to reflect the user's priority scheme. If not otherwise designated, a default set of constants can be employed which set the constants to zero for the constants attached to L, V, and H, respectively. These default values would set RWB equal to S.

Figure 1, Area Benefit Report, shows the format produced in Program 8 using test data for one period. This report shows the population for each unit area and the percentages of that population who (1) are normal (have no problems), (2) have problems, and (3) are lost (dead). These measures can be plotted as illustrated by Fig. 2, Population Plots, for up to 99 time periods. Figure 1 also shows the RWB for the previous time period as

well as the current time period. The differences between time periods are recorded under benefits added not only for RWB but for its components as well. A negative sign denotes a deteriorating effect. The readiness measure shown as RDY will be described in the next section and the concepts of cost and price will be described in a later section. RWB, RDY, RWB Price, RDY Price, S, L, V, and H may be plotted in a manner similar to that shown in Figure 2.

DATE = 05-15-72 BENEFIT REPORT PAGE NO. = 003

PERIOD = 1 TIME = 24.0 DURATION = .5 ZONE = 1 EOC = 1

AREA	TOTAL	---PERCENT---			---PRIOR STATE---			---CURRENT STATE---			---BENEFITS ADDED---					-- RWB	-POTENTIAL BENEFITS ADDED-					RDY
NO.	POP.	NORM	PROB	LOST	RWB	RDY	COST	RWB	RDY	COST	RWB	S	L	V	H	PRICE	RDY	S	L	V	H	PRICE
1	15586	.65	.29	.06	1.000	.000	0	.674	.273	0	-.326	-.05	-.40	-.36	-.36	0	.273	1.00	.04	.03	.02	0
2	10000	1.00	.00	.00	1 000	.000	0	1.000	1.000	0	.000	.00	.00	.00	.00	0	1.000	1.00	1.00	1.00	1.00	0

FOOTNOTES. RWB = RELATIVE WELL BEING RDY = READINESS COST = TEAMHRS S = SURVIVORS L = LABOR J = JOBS H = HOUSING PRICE = THRS/BEN

Fig. 1. Area Benefit Report.

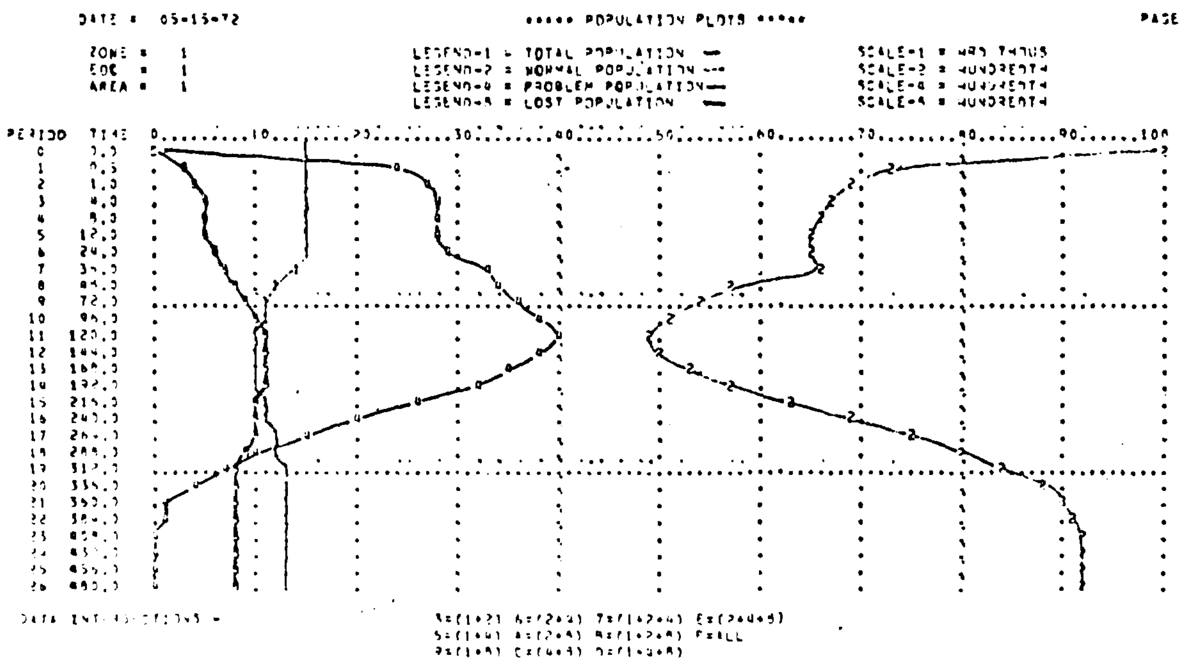

Fig. 2. Population Plots.

D. Readiness

Whereas relative-well-being (RWB) describes the relative state of the population at a point in the emergency period, readiness (RDY) represents a measure of the potential RWB based on the ability of the system to meet the demands for civil defense services. RDY contains terms very much like RWB but has one additional element. This new element measures the ability of the civil defense management to process problems in the four categories.

$$RDY = C \cdot S' \, (1 + L' + V' + H').$$

The evaluation of each of these terms is more complex than in the case of RWB above. In order to simplify the explanation, only one term L' will be described. The other terms are derived in a similar manner.

$$L' = (F_L + P_L)/P$$

where: L' = expected fraction of the total population with no health problems at the end of the next period;

F_L = population having no health problems;

P = total population;

$P_L = RX(B + B'Y)$,

where: P_L = expected number of people whose health problems are resolved during the next period,

R = patients-to-beds ratio,

X = expected fraction of demand for medical team-hours that are available or can be made available during the next time period,

B = number of hospital beds not threatened,

B' = number of hospital beds being threatened, and

Y = expected fraction of threatened beds made available during the next time period.

Constraints in this analysis are:

$F_L + P_L$ is not greater than P,

P is not equal to zero,

P_L is not greater than the health problem population,

X is not greater than 1, and

Y is not greater than 1.

This RDY measure and its component elements evaluate the ability of the present system to respond to the demands for civil defense resources. This measure is not proposed as an absolute measure but rather as a relative indication of system readiness. These measures may be plotted in a manner similar to that shown in Figure 2.

E. Team Effectiveness

If the performance of local civil defense operations is to be evaluated, other measures must be employed to complement the RWB and RDY values. A team effectiveness index has been developed to show how well each type of team performs. The effectiveness measure is developed from the product of three component measures which are considered relevant to a comprehensive evaluation. These component measures are: availability, reliability, and utility. They are defined as follows for each team, each area, and each time period being analyzed:

Availability, $A = \frac{t - \ell}{t}$;

Reliability, $R = \frac{a + m + i}{t-\ell}$;

Utility, $U = \frac{c}{a + m + i}$; and

Effectiveness, $E = ARU = c/t$;

where: t = total potential team-hours,

ℓ = team-hour losses,

a = active team-hours satisfying demand,

m = team-hours committed to movement, either for deployment to satisfy demand or redeployment (non-productive movements),

i = inactive team-hours, and

c = team-hours satisfying demand for both active team-hours and deployment team-hours.

Figure 3, Team Effectiveness Report, describes an output based on hypothetical data. This report has a line item for each type of team which is identified by a team number. The number of teams lost and surviving, together with the total team-hours available, gained or lost, and demanded are printed as a basis for the relative indices defined above. The team-hour demand distribution is displayed to the right of the demand column showing the fractions called "S " (shortage), "C " (completed), and "P " (pending). Next, the team-hours available distribution is displayed under the "A," "M," "I," "O," and "R" columns. The categories "A," "M," and "I" are defined above. Columns "O" and "R" are defined as the inoperative and restricted fractions, respectively, of total available team-hours. Each of the two distributions should account for 100 percent of total team-hours available and demanded. Using the appropriate column values, the indices described above are computed and displayed for evaluation.

DATE = 05-15-72 TEAM EFFECTIVENESS REPORT PAGE NO. = 01

PERIOD = 1 TIME = 1.0 DURATION = 1.0 ZONE = 1 EOC = 1 AREA = 1

TEAM			TEAM-HOURS			PERCENT												
NO.	LOSSES	SURVIVING	TOTAL	GAIN/ LOSS	DEMAND	S	C	P	A	M	I	O	R	AVAIL.	REL.	UTIL.	EFFECT.
2	63	104	104	3	327	.301	.284	.425	.850	.046	.085	.014	.000	.622	.981	.911	.556
12	112	499	499	-44	131	.000	.852	.148	.209	.014	.565	.212	.000	.817	.788	.283	.162
15	5	93	93	-5	1023	.925	.050	.035	.550	.000	.351	.100	.000	.950	.901	.561	.480
21	24	381	381	5	58	.000	.981	.019	.149	.790	.037	.025	.000	.941	.976	.153	.141
28	1	116	116	32	421	.599	.237	.164	.820	.043	.079	.056	.000	.990	.942	.912	.850
33	87	242	201	-87	975	.536	.156	.308	.000	.755	.202	.043	.000	.700	.957	.791	.530
34	230	368	344	-160	160	.000	.813	.197	.000	.380	.478	.142	.000	.601	.858	.441	.227
41	55	283	283	-42	0	.000	1.000	.000	.000	.000	.913	.087	.000	.864	.913	.000	.000
46	392	147	147	-24	98	.062	.715	.223	.456	.020	.186	.338	.000	.273	.662	.718	.130
47	191	501	501	-191	677	.246	.438	.316	.444	.148	.158	.249	.000	.725	.750	.787	.423

Fig. 3. Team Effectiveness Report.

The report generating procedure is able to generate similar reports for each EOC and for the zone at large. Moreover, an average or composite team is described as the last line item in the report. Although not now programmed, another report could be prepared summarizing the performance of each type of team over time. The team effectiveness reports should not be confused with the need for an overall local operating system effectiveness

report. The latter type of final evaluation report is beyond the scope of the current effort and should be generated from results developed in an evaluation model based on data not only from the countermeasures model but from the damage assessment model as well. Due consideration must be given to program objectives, resource inputs, attack scenario, analytical constraints, and cost.

F. Cost and Price

The notion of cost is extended to include the expenditure of team-hours. Team-hours are presumed to be a resource to be expended during an interval of time on a use-it or lose-it basis. The cost columns in the Benefit Report provide links with the Team Effectiveness Reports for the previous and current periods. They represent a measure of the number of team-hours required to achieve the benefits acquired during the two periods. Records of these expenditures and the effectiveness with which operational controls have managed them will be useful for identifying areas needing improvement.

Another indicator which may prove useful in systems evaluation is price. Cost (team-hour expenditure) measures are collected for both RWB and RDY related tasks. If these cost values are divided by their respective RWB and RDY values, a pair of potentially useful indices are generated. They will provide a measure upon which to base an estimate of preattack resource requirements. Analysis of the historical records from the countermeasures model should produce observable trends in resource requirements and aid in improved planning and training for civil defense operations.

G. Other Indices

The cost-benefit measures discussed in the previous paragraphs are believed to be the best measures of local operating system performance. Many other values can be produced in the output reports, if they are needed for overall system evaluation. However, other possible indices should not be developed until a specific need arises during final system evaluation.

III. LOCAL MODEL DESCRIPTION

A. <u>General</u>

The Local Countermeasures Model has been described in previous reports and its potential uses have been presented briefly in the preceding sections. This section updates the descriptions in previous reports. Although the description emphasizes the initial role of the countermeasures model--that is, the integration of all component subsystems--the model is readily amenable to performing the other roles identified in the introduction. In addition, the model has a capability by which submodels can be bypassed by using table-lookup techniques to generate performance data; however, for continuity the local model description will be presented as if the initial role is its primary role.

All activities performed by local civil defense forces must be in the Local Countermeasures Model for analytical results to be credible. Not only must these services be present, they must be sufficiently detailed to include all significant components and activities necessary to implement their assigned functions. Moreover, the interrelationships between functions and services must be identified if the effectiveness of the total civil defense system is to be determined.

These points are emphasized to draw attention not only to the desirability but to the necessity of defining a countermeasures model which can interface directly with functional subsystem models. Subsystem models are defined as models generated through component studies under other Divisions of the DCPA Research Directorate. For example, the medical service functional submodel programmed by RTI under a research project for another Division can be made effectively a part of the overall countermeasures model. Likewise, other models can be embedded in the analytical framework. Some functions of the local operating system--such as communication, transportation, supply, and control cannot be subordinate parts because they must coordinate the other functions.

The essential elements and the sequence in which they alter the states of resources are shown in Fig. 4, <u>Countermeasures Model</u>. As shown, the major part of these elements has been programmed. The problem definition model was programmed in COBOL for use on the CDC-3600 computer at the

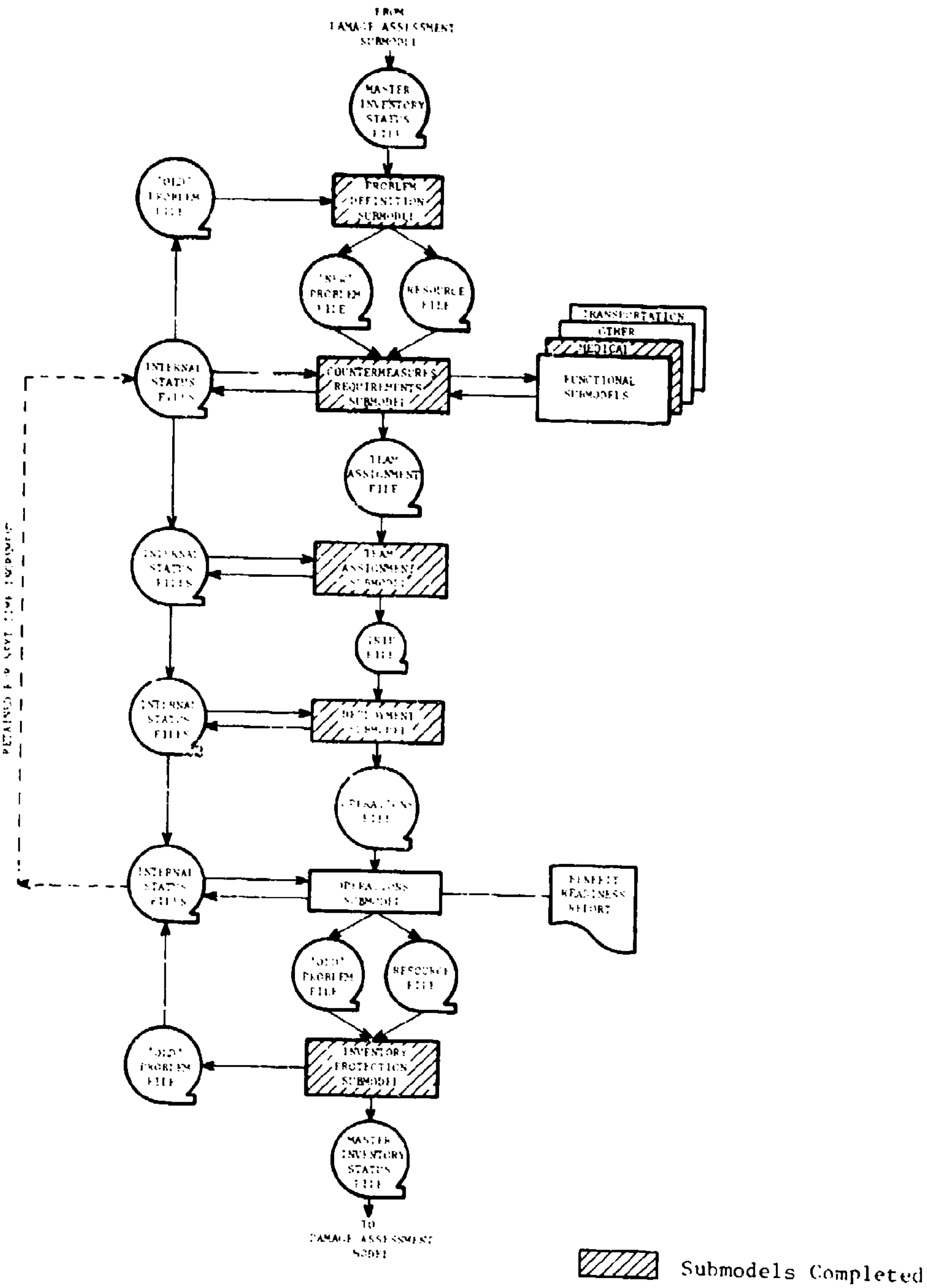

Fig. 4. Countermeasures Model.

National Civil Defense Computer Facility (NCDCF). As indicated above, the medical submodel has been programmed, and the requirements submodel with which it interfaces has been written and tested; both are on file at NCDCF. The transportation submodel has been partially programmed and tested to generate route and time values for the operations submodel. Communications are omitted for the present, but after the other structural elements have been completed, a communications submodel may be incorporated with no expected difficulty. The allocation function has relied heavily on the work done under Work Unit 1631[6/] to provide a means for controlling the simulated activities of the local system. After assignment of teams to operations, specific changes will be made in the states of resources. Control over these movements and the rate at which they take place has been provided in the deployment submodel; work on the operations submodel has been nearly completed. A reporting submodel has been added during the past year to take data from the operations submodel and prepare output reports describing population and readiness benefits and team effectiveness. These aspects of the local model were described briefly in the preceding section of this report entitled "Cost-Benefits Measures." Finally, the resources are redefined within the inventory file in terms which express their degrees of vulnerability to damaging environments. This model was programmed and tested at NCDCF. The first and last of these programs are designed to be compatible with the program developed by TOI[7/] and improved by IDA.

A more detailed description of each of the analytical procedures referenced above, beginning with problem definition, is given in the following sections.

6/ P. S. McMullan, et al. Budget Allocation for Shelter Systems, Final Report. OCD Work Unit 1631C. Research Triangle Park, N. C.: Research Triangle Institute, June 1967.

7/ Hans J. Tiller, et al., op. cit.

B. Problem Definition

Organization of civil defense countermeasures to meet undesirable situations begins with problem definition. Each resource in the inventory status file is examined with respect to its damage state and environment. A set of problems is identified which controls the type of operation to be conducted to solve or improve the prevailing situation. A counterpart of these problems is the availability of resources to implement proposed countermeasures. Shortage or damage to these resources, particularly injury to personnel, adds control and readiness problems to those already recognized as requiring remedial action. Availability of CD resource is defined by a resource matrix organized by land use or service function and resource type associated with each function. The output of the problem definition submodel is a problem file containing four general classes of problems. Records of two or more classes exist for each land-use entry within a unit area. Control and readiness problems are always present.

1. Control Problems

Problems that relate to the ability to identify, locate, direct, coordinate, or otherwise control the civil defense system are identified as control problems. One example is the inability to inform people due to the disruption of communication facilities; a second example would be insufficient information about the prevailing environment at a distant location under its jurisdiction; a third would be unassigned resources that may be useful elsewhere in the system. In some instances a problem may have been reported but insufficient information included to take appropriate action. Finally, problems unresolved at a lower control level represent a control problem requiring remedial action at higher level in the control system. All of these problems are assessed on the type "1" problem record. Many simplifications are necessary in a prototype design. For example, communication is assumed to be perfect. Thus, communication problems are deleted from the initial design, although the inherent capability to handle these problems remains.

2. Readiness Problems

Problems that relate to the vulnerability of people in a preattack situation or to personnel, facilities, and equipment required by teams are readiness problems. The availability of resources to meet other types of demand is increased by corrective actions in response to these problems rather than by yielding direct benefits. For example, if a team is inoperative because of a shortage of supplies, providing supplies does not necessarily mean benefits; however, they will in all probability yield benefits if the supplies are timely and used effectively. In some instances countermeasure actions may decrease the potential for injury to unprotected people. Thus, the solutions to readiness problems are extremely important to civil defense as a means by which the potential for gain is greatly improved. Problems of this type are entered on the type "2" problem record.

3. Damage Control Problems

Damage control problems, unlike other problem types, prevent the loss of a resource or its utility rather than improving an already degraded condition. Examples of this type of problem include fire-fighting, decontamination, and debris clearing. Operations formulated to resolve these problems provide benefits derived from the salvage of resources which would otherwise be lost. For example, the use of shelter spaces, pumping stations, and residential units within an area may require damage limiting operations to remove the threat of fire-spread.

4. Relief and Rehabilitation Problems

This class of problems, which relates directly to the state of people, consists of shelter, rescue, treatment, and rehabilitation problems. It sets the standard for measuring the degree to which human life has been disrupted. All other problem groups must relate to this one and in this sense are subordinate to it. Damage control problems become meaningful by the degree to which they prevent the

type of problems recognized by this group. Moreover, increased readiness and control problems become meaningless unless they reflect an inability to cope with either damage control or relief and rehabilitation problems. Since this last group represents the most important set of problems, it has been the primary subject of the model-building effort within the countermeasures model. Important consideration has been given to readiness problems associated with relief and rehabilitation problems.

In a dynamic evaluation of a local civil defense system, problems change from one period to another; therefore, problem definition not only requires identification of a problem, but details of its magnitude and rate of change. Some problems which remain unsolved may deteriorate into different or more severe problems (e.g., they may spread from one area to another); they may even disappear altogether with or without adverse effect. Recognition of this dynamic character is one of the significant differences between the system model now being developed and previous models. As a consequence, the output from the problem definition submodel contains a problem change file which denotes the increase or decrease in the number or magnitude of problems over those existing in the previous period. Only when new problems have been recognized can requirements for appropriate civil defense activities be generated.

C. Alternative Solutions

The first function of the requirements submodel is to update service records and verify increased readiness and control problems. After updating, sufficient information is available to prepare alternative assignments. These assignments are inputs to the various functional submodels. This requirements submodel has been written to include a table-lookup capability which can be used instead of submodels to generate resource requirements. If selected, a procedure is available that will link the detailed medical treatment[8/] and transporation submodels which are described in Sections III.D and III.F.

8/ J. N. Pyecha, et al. User's and Operator's Manual for the Local and Aggregate Total Emergency Health Care System Models. Final Report R-OU-407, Volume II. OCD Work Unit 3432B. Research Triangle Park, North Carolina: Research Triangle Institute, October 1970.

1. Service Status File

It is possible to update the service file with respect to the status of teams by examining the resource and the "new" problem files. For example, if a change due to injury, entrapment, or other mishaps reduces the number of eligible civil defense people, adjustments in the number of teams and, perhaps, their functions and state distributions are necessary. Updating is also necessary if the magnitude of a problem has decreased, so adjustments would have to be made in existing assignments and then in team states. An example of the need for updating in service status is the death of people scheduled for rescue while teams are enroute to the site. Therefore, the status of teams may change from active to inactive, pending reassignment. Changes in equipment or supply are made by updating the service status file and by noting any new increased readiness or control problems. After updating, appropriate records are selected for processing through each functional submodel.

2. Functional Submodel Input Processor

Initially, two functional submodels (medical and transportation) are being incorporated in the overall countermeasures model. Each requires a separate input file. To add depth to the operational alternatives offered by the model, other functions (e.g., rescue, casualty collection, remedial movement, and shelter) are incorporated in a simplistic fashion by table-lookup. The medical description assumes the existence of a set of records containing the number of teams available, quantity of supplies, and the type of injury, as well as identification and general data about the unit areas. The requirements submodel generates this data set from the resource, problem, and assignment files as an input to the medical submodel. After processing the input files, the functional submodel generates an output that is processed by an output file processor to generate data used by the assignment, deployment, and operations submodels of the Local Countermeasures Model.

3. Functional Submodel Output Processor

Following functional evaluation of a problem's demand for resources, the outputs are redefined for the assignment record. A typical output processing task can be illustrated by outputs from the medical submodel. Data items received from the medical submodel are the number of casualties treated and not treated, the number of deaths expected in each group, supplies used, team-hours used by each team assigned, and the number of transfers. These items are entered or redefined as required on appropriate functional assignment records. After all functional submodel output is determined for all unit areas, control is passed to the team assignment submodel to evaluate assignment or reassignment of teams to specific operations.

D. Functional Submodels: Medical Submodel

Two computer simulation models designed to assist medical preparedness planners in analyzing postattack health consequences were developed by RTI under OCD Research Project 3432B.[9/] One of these models, the Aggregate Total Emergency Health Care System Model (the Aggregate Model), can be applied in the study of health related problems at the county, area, state, regional, or national levels.[10/] The other model, the Local Total Emergency Health Care System Model (the Local Model), is designed for studying single localities--a town, a city, or a one- or two-county area in which detailed results are desired for each Standard Location Area (SLA). The Local and the Aggregate Models, although they differ considerably in logic flow, are similarly designed; each has two submodels or programs that provide essentially

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9/ J. N. Pyecha, et al., op. cit.

10/ County, area, state, or region designations are used in this report as defined by the National Location Code (NLC) prepared by the Bureau of the Census for the Defense Civil Preparedness Agency (formerly OCD). In order to prevent any ambiguity in the use of these terms, a NLC area or region will be designated as a DCPA area or DCPA region, respectively. No distinction with regard to the use of the terms "county" or "state" is required.

the same type of output for their respective geographic areas: (1) an immediate effects submodel is directed toward improving the prognosis of the immediate weapon effects injuries for days 0 through 30, and (2) a communicable disease submodel is directed toward prevention and cure of disease epidemics for days 31 through 365.

An excellent opportunity for demonstrating a practical interface between component studies and a total systems evaluation model is offered by adaptation of this model for use in the Local Countermeasures Model. To that end, this model was selected and programming was initiated (see previous sections on the functional submodel input and output processors).

1. Immediate Effects Submodel

The immediate effects submodel simulates the sorting and treating of seventy-two casualty types that might survive a specific nuclear attack. Prognosis of death is based on the injury type, the radiation dose, the availability of medical supplies, the level of treatment received, and the time delay in initiating treatment. These delays are due to (1) dangerous radiation fallout fields, (2) transporting supplies and casualties, and (3) reestablishing a minimum organization. The number of deaths and survivors of the 30-day immediate effects phase, along with the utilization rate for medical supplies and personnel, are outputs.

A prognosis of survival is applied to each set of injury problems. Input data defined for each injury type specified in the medical caseload include: (1) the time required for treatment at the surgeon, physician, and allied medical personnel levels; (2) the time span after which initiation of treatment is of no avail; and (3) the prognosis at each treatment level or if no formal treatment is undertaken. Output goes to the functional submodel output processor (referred to in the previous section). A detailed description of this submodel can be found in the referenced report by RTI.[11/] Although not presently contemplated as a part of the total systems evaluation model, the communicable disease submodel is likely to become a part of it and, therefore, is worthy of brief comment.

11/ I. N. Pyecha, et al., op cit.

2. Communicable Disease Submodel

The communicable disease submodel evaluates the first 30 days in the postattack phase. The submodel, using a mathematical description of infection, subjects survivors of the immediate effects phase to the risks of becoming infected by one or more of eleven communicable diseases. The variables include radiation dose rate received by casualties, geographic area involved, time of year (seasonal variation), and general postattack conditions. A prognosis function, based on the disease type and the availability of medical personnel and supplies, is applied and estimates of infectives and fatalities, along with the allocation rate for medical resources, are made in chronological periods of from one to five days. Death rates by disease type are adjusted to reflect current status of medical resources; for example, the severely irradiated will develop problems more quickly than the other groups and, therefore, will use resources first. Outputs are similar to those for the immediate effects submodel; however, the number of "infectives" by disease type is substituted for the number of casualties by injury type.

3. Medical Submodel Outputs

Although the immediate effects and the communicable disease submodels are not alike in detail to each other or to the other functional submodels, they both do possess similar characteristics such as the specifications of such common outputs as (1) team-hours demand, (2) supply items demand, (3) transfers (demand exceeds capability), and (4) expected losses or state changes.

E. Resource Assignments

Both the file configuration and the data management techniques being developed in the requirements submodel are needed to prepare the team assignments. A new record is created to describe each operation required to solve a defined problem set. The number of teams and the average time each team requires to implement each operation and to secure the desired benefits are derived from functional submodels or table-lookup. These values are

used, subject to constraint, to determine assignments for all teams under the jurisdiction of a specified control point. This allocation procedure,[12] an adaptation of an efficient algorithm developed by RTI,[13] assigns resources to alternative programs. Demands not assigned are retained for subsequent allocation of unassigned resources in later periods. Provision has been made to permit externally assigned priorities to override internally assigned priorities. After all assignment decisions have been made and new and old operations records have been combined, the evaluation procedure enters the operational phase for the deployment of resources and the execution of mission assignment.

F. Resource Deployment

Deployment planning for team and supply distribution over the network of lines and links is necessary in total countermeasures system analysis. Planning leads to the proper and efficient assignment of resources. Short cuts are contemplated which would permit a choice between estimating arrival times and determining them in a queuing model. The minimum route procedure has been programmed in FORTRAN, but it has not been adapted for the route selection procedure described in Section III.F.4. Thus, the selection of operations and the assignment of teams to trips are presumed to have been accomplished before deployment.

1. General Description

Because an important aspect of a dynamic system is the movement of resources from one area to another, movement to shelter, as a countermeasure concept, cannot be evaluated satisfactorily without some form of transportation submodel. Although, the present model

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12/ P. S. McMullan, et al. Budget Allocation for Shelter Systems, op cit.

13/ P. S. McMullan, et al. An Algorithm for Maximizing Cost Effectiveness of Civil Defense Shelter Development Programs. Work Unit 1631C. Research Triangle Park, North Carolina: Research Triangle Institute, October 1966.

does not utilize the general queuing model procedure which is described in the following paragraphs, it is planned to incorporate this procedure at some future date. Therefore, the prototype version assumes that predicted minimum travel times without traffic delays are realized. The queuing model will enable a time-related set of moves to shift resources about the network and determine the delays due to traffic congestion.

2. Minimum Route

A minimum route file is generated in the transportation submodel for all moves between admissible origins and destinations within a network. Selected minimum paths consider network problems (radiation, blocked streets, traffic jams, speed-reducing debris, etc.) evident in the queuing model for the immediately preceding period. This route file is the source of all movement time entries in trip records.

Special procedures are being derived for dealing with the relatively large networks. Present estimates contemplate over 300 major artery links for the Detroit Metropolitan Area network. Since this area is too large to be managed as a single network, four levels of networks coinciding with the organization structure have been devised. Level 1, which corresponds to the sector, is a network linking unit areas within a sector; nodes (otherwise identified as link terminals) which are interior and do not appear in another network are labeled level-1 nodes. Level-2 nodes are exterior, or sector boundary points. Level-3 nodes are level-2 nodes which are also group boundary points. Level-4 nodes are both level-2 and level-3 nodes and are zone boundary points. Level-5 nodes are also zone boundary points, but at the local level of analysis they are recognized only as level-4 nodes. These levels allow one to structure a network of minimum routes (rather than links) and to determine movements over large networks.

3. Trip File Generation

Resource availability and functional capability are the two main criteria for generating movement requests. If the environment prevents functional performance or resources are not available in a specific area, neighboring areas are searched to establish minimum time moves that resolve these problems. Searches are conducted in order of operational priority and two trip records are generated. The first is used to subtract resources at the origin and the second is used to add resources at the destination. If arrival times have not been reached at the end of the current period, the resources are placed in an "in-transit" status. The trip file is the primary input to the queuing model. The purpose of the queuing model is to determine whether the planned trip departure and arrival times can be executed over the transportation network. Delays due to traffic congestion are acknowledged by altering either or both of these times.

4. Queuing Model

Basically, a trip is defined as a move in which some resource takes a path (represented by the link) through an environment. The link has four properties: (1) a gate which processes trips one at a time, (2) a queue which orders the trips through the gate, (3) a pointer which guides the trip to other links, and (4) a generator which originates new trips for the networks. The submodel maintains two lists of pending events (origination and process completion); each list has an entry for each link. The next event is the minimum positive entry in either list.

Initially, origination times are set to zero, process completion times are set to minus 1, and all links are set idle. The originate routines must be entered first to place trips in queue and to determine the time-to-next-origination for the originations list. The idle indicator requires that a trip be selected for each link and that the process time be determined for the process completion list. Control is governed by the advance of "simulated" time and by the event times on either of the two lists.

The "simulated" time enters the link's originate routine if it reaches a time in the origination list. This routine generates the required trip descriptors and the time-to-next-origination. The former is placed in queue; the latter, in the originations list.

If "simulated" time is reached in the process completion list, the link's disposal routine is entered to define the link numbers by which the trip is routed and places them last on its queue. The link is labeled "idle" if the "trip" queue is now empty; if not, control goes to the queue select routine to find the position of the next trip for processing. (Note: If first-in-first-out, the next trip in queue will be processed next.) The selected trip descriptors are moved to the working location and the process time is determined by the process routine. The "process" time is added to "simulated" time and placed on the process completion list.

Maximum queue lengths can be specified by using a special feature of the disposal routine. Trips are retained in the present link, which will become temporarily idle until the queue at a specified link decreases.

5. <u>Operational Deployment</u>

Using the queuing model described above and the trip file, resources are moved over the network. Starting with the highest level network, movement proceeds until all are at the lowest (or the unit area) level. Unforeseen delays require that arrival times be adjusted for positions attained during the time interval. Statistics are prepared for each link. Information from this queuing process will be used for planning movements in the assignment model during the next time interval. Thus, decisions are being influenced constantly by events in the immediate past. (Correspondingly, fallout prediction data could be made to influence routing by formulating predictions in a way similar to that described above; however, this prediction option is not planned for the local model now being developed.) Deployment is completed to determine arrival times for teams performing assigned functions.

G. Operations

Normally, deployment with or without the queuing model is made possible at the beginning of the operations phase at rates specified by two trip records generated in the deployment submodel. These two records are sorted into origin and destination locations in a sorting operation between the deployment and operations submodels. Operations records are processed by priority in the presence of assignment records organized by area, operation number, and land use. Changes in resource states are recorded in the benefit, problem, and resource files. Changes in system performance are recorded in the benefit and readiness files.

This procedure is nearly completed. It, together with the tranporta-tion submodel, are the last elements needed to complete the prototype Local Countermeasures Model. However, no significant problems are expected in completing these submodels. The benefit file is used in the report submodel to describe benefits, readiness, and team effectiveness. The changed resource and problem files are input to the final step in the countermeasures model before redefining the resource status and recording the vulnerability in the inventory status file.

H. Cost-Benefit Reporting

During the reporting period, a report generating procedure was programmed and tested using hypothetical data. This program uses two files. The first is a performance file generated in the operations submodel. It contains team performance information, population benefits, and readiness data. The second file contains historical cost-benefit data from previous periods.

Data from these two files are processed and the cost-benefit measures described in Section II are developed and displayed in two reports, the Benefit Report (Figure 1) and the Team Effectiveness Report (Figure 3). In addition, the program has the capability of plotting data on the Benefit Report to allow visual scanning for significant changes. The plotting procedure can plot four (4) data sets for each time period. An example of this form of output may be seen in Figure 2. Four different sets of plots may be produced displaying the values of 16 data elements.

As the countermeasures model is integrated with the evaluation model, additional data requirements are likely to evolve. If so, then this report generating procedure probably will be altered to meet these new needs.

I. <u>Inventory Protection</u>

Where the people are located (e.g., in single family residential units or NFSS shelters) determines the protection level or, conversely, the vulnerability level of people. People are loaded into shelters and inventory records are prepared according to the control policy and posture constraints prevailing at each location. This submodel, programmed for the CDC-3600 computer at NCDCF, uses the problem and resource files from the operations submodel to update the status of resources in the inventory file developed by Technical Operations, Inc. (TOI) for their damage assessment model. Three files (problem, resource, and inventory) are manipulated to update the inventory file. The inventory file is described here to emphasize the significant aspects of this interface. If area data remains unchanged, the file is transferred directly to the updated file; structural data and area situations are generated from the master inventory and problem files; personnel records are generated largely from the problem file; resource records are generated from both the resource and the master-status files; and shelter space records are transferred from the master-status file (MSF). The final function of this submodel is to fill shelter spaces according to the control policy and to record the protection factors for the occupants.

At this point in the evaluation, one pass has been completed by the countermeasures model by taking the master-status file from the damage assessment model and delivering back to it an equivalent file. This file was modified to reflect civil defense countermeasures during the specified time interval. In the course of planning and executing the specified countermeasures, a number of files were created, modified, and retained for the next process period. Processing continues until the number of time periods required by the system control model terminates the simulation. A large number of printout options provided within the submodels

yield a running description of system performance. Output data may be processed at the conclusion of each pass or at the time of termination.

The MSF contains most of the information in the data base. It is a vital part of the local systems analysis as evidenced in the following discussion.

J. Damage Assessment

A brief description of the Local Damage Assessment Model (LDAM)[14] is abstracted here to enable the reader to follow the entire procedure planned for local system simulation. If desired, the user may intervene either before or after executing the LDAM.

The model applies prompt and persistent effects of one or more nuclear detonations to each unit area and to each area's resources. Since the model is executed once for each time increment, damage and casualties are assessed for each unit area in turn.

The LDAM interfaces with the attack model, which provides input for necessary environmental effects data. The fire-spread submodel in LDAM updates the MSF for fire-spread and fire casualties. The initial MSF, organized by unit area, contains the target area description (TADF), the inventory status (ISF), and personnel status records and furnishes input for the LDAM.

Six submodels of LDAM perform the following functions: (1) apply prompt effects to the target area, (2) apply prompt effects to the inventory, (3) apply persistent effects to the target area, (4) apply persistent effects to the inventory, (5) apply fire effects to the target area and inventory, and (6) summarize and generate reports. The LDAM updates the MSF for each unit area and time increments. In all unit areas the prompt effects of the initial detonation are assessed for both target area and inventory; then persistent effects are assessed for unit area and by single time increments unless additional nuclear detonations occur or the transattack

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[14] Hans J. Tiller, et al., op. cit.

period ends. If additional nuclear detonations occur, prompt assessment is performed before continuing the persistent effects assessment. Damage, casualties, entrapments, and debris levels are determined on the basis of triptychs or multitychs, which indicate the degree of damage and casualties from blast, fire, and radiation by structure type, personnel posture, and type of casualty according to the effects data provided by the attack output and the fire-spread output. At the end of each time increment, output of LDAM is the updated MSF; these records reflect the current situation including availability and the condition of resources. Either all data in the file or certain selected records may be printed.

IV. DATA BASE

Preparation of the data base (master inventory file) required by the submodels of the Local Countermeasures Model was begun two years ago. Efforts last year concerred revising and updating the existing data base and preparing data files needed for the submodels programmed that year. This year, items of the data base needed by the submodels were revised and the trial data base enlarged. As more submodels of the Local Countermeasures Model were programmed, data files needed for execution purposes were created and stored either on disk or entered as card input.

The trial data base has been developed from real data about Detroit, Michigan. This data base covers eight (8) of the two hundred and eight (208) unit areas in the six-county area of Detroit. Generally, these unit areas were formed according to their Zip Code boundaries. Information contained in the data base file for each unit area includes the following:

(1) Latitude and longitude of the unit area.

(2) Areas of land parcels in 64 selected land-use classes.

(3) Building density and structural type distribution for each land use class.

(4) Population distributed by land-use class and civil defense teams.

(5) Shelter spaces by PF category for above-ground and below-ground shelters.

(6) Equipment for fire-fighting, communications, transportation, medical treatment, etc. (74 codes).

(7) Food (rations) estimated available in restaurants, retail stores, and wholesale warehouses.

(8) Potable and nonpotable water.

(9) Major transportation arteries (highways, railroads, waterways).

Since the trial data base covers only a few unit areas, this data base should be expanded to include all unit areas in the Detroit metropolitan area. Subsequent effort should focus on the evolution of a "typical" data base which could be applied to any operating zone. If a few key local parameters are generated and processed with the "typical" data base, a particular local data base can be synthesized suited to the selected mode of operation for the Local Countermeasures Model.

V. DISCUSSION

This section contains a general discussion of the Local Countermeasures Model, its development status, and the methodology used to achieve its objectives.

The model being developed by RTI has been directed toward the evaluation of many individual countermeasures integrated into a total operating system. Heretofore, system evaluations have concentrated on individual countermeasures; other countermeasures have either been omitted or included only in supporting roles. Thus, this evaluation procedure is designed to integrate all countermeasures into one system.

The concept of a countermeasures model is embedded in a larger concept of a system to test and evaluate local operating systems (TELOS). TELOS has been described as having four roles or applications. They are:

(1) Coordinate component research contributions to Local Operating Systems.

(2) Prepare damage functions for national assessment of civil preparedness.

(3) Support training of local civil defense through operation simulations.

(4) Evaluate alternative local operating plans and procedures.

The test and evaluation procedure is described concisely in Fig. 5, TELOS Flow Chart.

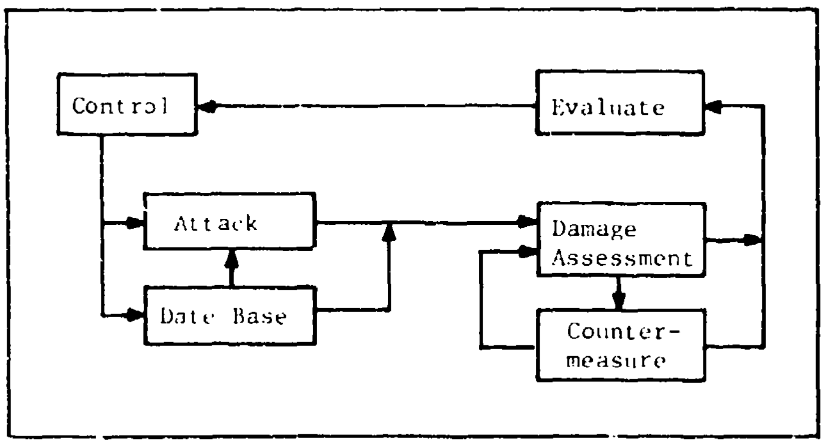

Fig. 5. TELOS Flow Chart.

Briefly, the system functions under a set of controls which governs an attack model which generates overpressure, thermal, and nuclear radiation levels at various points over the entire local area. The local area is described by a data base that can be varied by control inputs. The local damage assessment model (LDAM) relates the resources to the environment levels and describes the resulting damage. The Local Countermeasures Model (LCM) responds to problems derived from an examination of resource damage. Through various countermeasures, it either protects resources from subsequent damage or relieves the distress resulting from the consequent damage. In either case the state of local resources is altered.

An iterative process between the countermeasures and damage assessment model conducts operations through a number of time periods by system control. An evaluation model analyzes the outputs from both LDAM and LCM with respect to the particular role of TELOS. On the basis of this evaluation, controls for further data generation are determined and a new cycle begins. If evaluation goals are achieved, appropriate reports are generated reflecting the outcome with respect to these goals.

The status of the countermeasures model program may be described as in the late development stage. Progress has been evolutionary. Work has progressed slowly and in an orderly way toward the objective--development of a total local civil defense evaluation system. As the model has evolved so have the uses described above. Thus, the prototype countermeasures model is approximately eighty-five percent (85%) complete. (An exact estimate is difficult, or impossible, because the desired product is not precisely defined and the roles are not stated explicitly.) The character of the model has changed during the course of development and is likely to continue to change.

Several simplifying assumptions have been either adopted or recommended for adoption to allow earlier demonstration of a prototype model. First, communication problems have been considered but not incorporated in the model. Second, the use of reference tables instead of submodels is urged. even though this implies displacement of the first role as the most

important role of the model. Many other less obvious simplifications have been made throughout the design to shorten both development and running time without loss of realism and to make this simulation of a complex system more practicable. Care has been taken to insure that a relatively high degree of flexibility is retained; elements bypassed for expediency may be restored without negating the fundamental approach underlying the model structure.

As work proceeds, considerable effort will be exerted to refrain from making major changes until the prototype has been completed. Many improvements will be withheld for a second version of the analytical framework.

Figure 6, Local Countermeasure Model Program Description, describes concisely the process used to generate local operating system benefits.

LDAM was added at the end of this program description to show that the output from the Local Countermeasures Model goes into this model. LDAM could have preceded the LCM. It is significant to show LDAM last; implying that LCM includes the potential for performing countermeasures before an attack as well as after one. Although the prototype version was originally designed for transattack operations in response to damage problems arising in the immediate postattack period, it has an ability to respond to anticipated problems arising in the preattack period, if they are appropriately defined. One of the earliest improvements in the LCM should include changes incorporating these definitions.

A detailed development, test, and evaluation plan is needed to guide progress toward the utilization of the Local Countermeasures Model for most, if not all, of the roles discussed above.

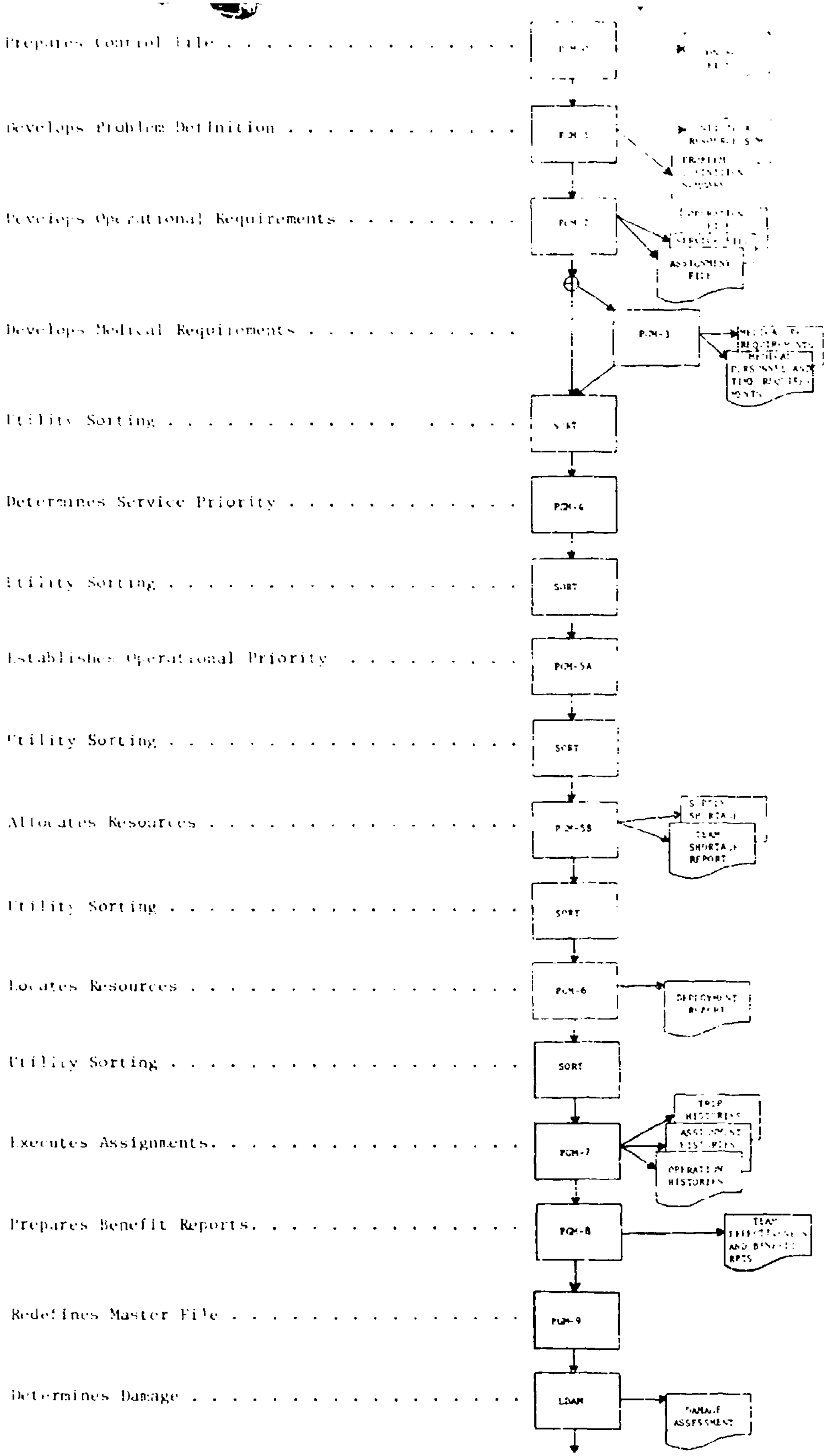

Fig. 6. Local Countermeasures Model Program Description.

VI. CONCLUSIONS AND RECOMMENDATIONS

The preceding sections support the conclusions that explicit guidance is needed to define the roles of the Local Countermeasures Model in system evaluation. RTI recommends that the control of inputs and the evaluation of the outputs be developed based on the role definitions for the TELOS system. A very important part of this effort is to examine alternative roles and to determine the system requirements for these roles. Thus, the system objectives will determine, through stated requirements, the nature of the controls to be imposed on the damage assessment and countermeasures models.

Recommendations for completion of the prototype development model are that a multi-year program be developed and implemented to realize all the potential benefits from the Local Countermeasures Model; the transportation and operations submodels be completed and thereby, acquire a prototype version of the Local Countermeasures Model; the Local Damage Assessment Model (LDAM) developed by IDA be combined with the Local Countermeasures Model for smooth operation; a complete detailed local data base be developed to support this effort; and the ability of the system to process local operating data and generate output information suited to the test and evaluation of alternative operating tactics be demonstrated.

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